Ultrasound arthroscopy of articular cartilage in human shoulder joint in vivo

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INTRODUCTION

Arthroscopic evaluation of articular surface is based on visual inspection and manual mechanical probing. However, as a subjective investigation arthroscopy is highly dependent on the experience of the operating surgeon. In a recent study, the majority of experienced arthroscopists found it difficult to discern between high and low grade cartilage damages. A device providing a quantitative measurement of the integrity of the articular cartilage was considered useful.

Quantitative ultrasound arthroscopy has been suggested as a method for evaluating the integrity of articular cartilage. In laboratory, high frequency ultrasound has also been used successfully to evaluate severity of cartilage injuries and to detect osteoarthritis in its early stage. In this study we evaluated the feasibility of quantitative ultrasound arthroscopy to detect different cartilage defects in human shoulder joint in vivo.

MATERIALS AND METHODS

Patients (n=9) undergoing arthroscopic surgery of the shoulder joint were enrolled in this study. Both humerus and glenoid cartilage surfaces of the joint were measured during the normal arthroscopic procedures. At the measurement site articular surfaces were classified according to the International Cartilage Repair Society (ICRS) grading system. A high frequency (40 MHz) clinical intravascular ultrasound system (ClearView Ultra, Boston Scientific Corporation, CA, USA) was used. The radiofrequency signal obtained from the ultrasound device was collected with 250 MHz sampling frequency using a digital oscilloscope (LeCroy, Wave Runner 4XGi-A, NY, USA). Then it was stored for the off-line analysis using a custom-made LabView-software (National Instruments Corporation, TX, USA).

Reflection coefficient (R), apparent integrated backscattering coefficient (AB) and ultrasound roughness index (URI) were calculated for each measurement site. Ultrasound images at 26 measurement sites were used to determine the "ultrasound score", corresponding to the ICRS grading system. Further, a musculoskeletal radiologist, using the clinical MRI of the shoulder joint, determined the cartilage at each measurement site either to intact or damaged. The ethical review board of Helsinki University Hospital accepted the study plan (permission 103/13/03/02/09).

RESULTS

Quantitative ultrasound imaging revealed different characteristics of the articular surfaces in the glenohumeral joint (Figs. 1 and 2). Ultrasound reflection (R and IRC) from damaged cartilage (n=9) surface decreased compared to intact cartilage (n=17) (Mann-Whitney U-test, p=0.033 and p=0.043, respectively). Surface roughness (URI) and AB measured from damaged cartilage were not significantly different from those of intact tissue.

Significant negative correlations were observed between the arthroscopic ICRS grade versus R and IRC (Spearman’s correlation test, r = -0.444, p=0.023 and r = -0.426, p=0.03). There was a positive correlation between the ICRS grade and the corresponding "ultrasound score" (Spearman’s correlation test, r=0.472, p=0.015). The MRI grades were not significantly correlated with any parameter collected in the study.

DISCUSSION

Surface reflection parameters (R and IRC) were lower for damaged cartilage than for intact tissue, consistent to previous in vitro, ex vivo and in vivo studies.

In 10 out of 26 cases the "ultrasound score" yielded higher grades and in 2 out of 26 cases lower grades compared to the ICRS grading. Subchondral bone is visible in arthroscopic ultrasound images of damaged cartilage, enabling measurement of the lesion depths. This makes the decision between the ICRS grades 2 (thickness >50% of intact) and 3 (thickness <50% of intact) easier.

To conclude, ultrasound imaging of shoulder articular cartilage was applicable during arthroscopy. The diagnostic potential of arthroscopy for cartilage lesions may be enhanced by arthroscopic ultrasound imaging. However, further technical development of arthroscopic ultrasound catheters is needed to enable more straightforward clinical measurements.

REFERENCES